Printing Paper and a Meth d for Manufacturing the Same

The present invention relates to a method for manufacturing a printing paper. The method comprises the surface sizing and calendering of base paper containing mechanical pulp and/or recycled fibre. The invention also relates to surface-sized printing paper, in which the base paper contains mechanical pulp and/or recycled fibre and filler 10 to 40 wt-% of the total fibre content, the surface roughness of the printing paper being 2.0 μm at the highest (PPS-10 method).

Background

Publication US 3,982,056 discloses a paper coated on one side, the printability of which paper is improved by moistening the uncoated side of the paper and conveying the paper thereafter to a gloss calender, in which the coated side is brought in contact with the smooth surface of a hot roll. The aim is to obtain printing properties of similar quality than those of supercalendered paper.

Publication US 6,013,359 discloses a printing paper, especially a newsprint coated either with polyacrylamide or acrylamide/metacrylamide copolymer. The amount of coating is 0.01 to 0.2 g/m^2 per side. After the coating process the paper is supercalendered.

It is a problem of known coated printing papers such as LWC papers that the raw material base is expensive because of large amount of pulp that is necessary and the large amount of coating material. The use of printing papers with less expensive raw material base is, in turn, restricted by the fact that the print does not have the desired quality. When supercalendered paper (SC) is used as printing paper the screen dots in the areas between the fibres are not repeated in a sufficiently intact state. This can be affected by calendering the paper more efficiently, but this can result in blackening by calendering and/or clusters of screen dots i.e. so-called galvanized print.

Summary

By means of the printing paper and method according to the invention for the manufacture of the same, it is possible to avoid the above-mentioned problems. The printing paper according to the invention is characterized in

that the amount of surface treatment agent is under 2.0 g/m^2 per side. The method according to the invention is characterized in that the base paper is calendered before surface sizing in a calender that comprises at least one nip that is formed between a hard-faced roll and a soft-faced roll.

By means of the method according to the invention a priting paper is attained the properties of which are better than those of conventional supercalendered paper, and the paper according to the invention can be utilized to replace known coated paper grades, such as LWC paper. The printing paper according to the invention can be printed by offset with printing inks used in connection with LWC papers. It is also possible to use so-called dry offset method when printing said paper. The above-mentioned advantages of printing paper are mainly based on the good dry surface strength of paper attained by means of the method according to the invention. When compared to other coated papers, the consumption of the surface treatment agent is very small. As a result of the afore-mentioned fact the need for drying the paper is very small as well. The advantage of gravure papers is that the pores of the printing paper manufactured with the method according to the invention are closed in such a manner that the evenness of absorption of the printing ink is improved.

As coated printing papers can be at least partly replaced with uncoated, surface-sized printing paper manufactured by means of the method according to the invention, investments in the papermaking line in connection with surface sizing are small when compared to investments required by coated printing papers.

The basic idea of the method according to the invention is to calender the base paper before coating the same with the surface sizing agent so that the base paper obtains such a smooth and pore-free structure that as small amount of surface sizing agent as possible is consumed, and nevertheless, a printing paper with good printing properties is obtained. The paper according to the invention can be used both as an offset paper and gravure paper.

Detailed Description

Paper with surface roughness of 5.0 to 7.5 μm when measured with the PPS-10 method is used as base paper. The raw material content of the base paper can correspond to typical supercalendered (SC) printing paper. The fibre content of the base paper is typically 70 to 90 % by weight of mechanical pulp, such as groundwood or refiner groundwood, and 10 to 30% by weight of pulp. Part of the mechanical pulp can be replaced with recycled fibres. The fibre content can contain 15 to 40 % by weight of filler, such as clay mineral, talc or calcium carbonate. The grammage typically varies between 39 to 80 g/m^2.

The base paper can also be such paper that comprises mechanical pulp and/or recycled fibre over 90% by weight, advantageously over 95% by weight of the total fibre content of paper. The fibre content of the base paper may also consist entirely of mechanical pulp and/or recycled fibre. Because the use of chemical pulp in paper improves for example the strength properties of the paper, the use of fillers, in turn, weakens the paper, as the amount of chemical pulp is reduced, the amount of filler is advantageously also smaller, for example 10 to 15 % by weight of the fibre content.

The base paper is calendered before it is coated with the surface sizing agent in such a manner that the surface roughness is typically 1.0 to 1.3 μm. The calendered base paper is coated with a surface sizing agent that is used 3.0 g/m^2 per side, advantageously under 2.0 g/m^2 per side, most advantageously 0.5 to 1.5 g/m^2 per side. The amount of 0.5 g/m^2 per side is not necessarily the minimum value of the most advantageous area, but the minimum value can be even 0.3 g/m^2 per side. Advantageous results have been attained for example in the range of 0.3 to 1.0 g/m^2 per side. The presented amounts of surface sizing agent represent dry matter contents.

In the method according to the invention the base paper is first treated with a calendering treatment to reduce the surface roughness. Thereafter the base paper is surface sized with a surface sizing agent, and the attained surface-sized paper is calendered again lightly so that a suitable smoothness of the surface is attained after the surface sizing. The surface sizing agent is substantially free of mineral substances, such as kaolin.

Suitable surface sizing agents include water-soluble adhesives, such as carboxy-methyl cellulose (CMC) or starch, different kinds of latexes, different kinds of waxes and mixtures of the above-mentioned agents. Especially the mixtures of starch and some other agents such as plastic pigments (for example styrene/acrylic copolymer particles, particle diameter 1.0 µm, such as Ropaque HP-1055, Rohm & Haas), styrene/acrylate latex or styrene/butadiene latex are especially advantageous in relation to the printability of offset paper. For offset printing paper starch is an especially advantageous option as a surface sizing agent.

The base paper is calendered before it is surface sized with the surface sizing agent in a calender with more than one nip. The calender comprises at least one nip that is formed between a hard-faced roll and a soft counter surface. The hard-faced roll is typically a heated metal roll. The soft counter surface can be for example a roll with a paper surface, a roll with an elastic surface, a belt or a shoe roll. The surface of an elastic roll is typically composed of a polymer surface.

Advantageously the calendering is conducted in a supercalender or multinip calender. In connection with the calendering it is possible to moisten the paper with steam or by spraying water. The term supercalender refers to a calender with several nips in which hard and soft rolls alternate. The supercalender may also contain nips, typically only one, in which the nip is composed between two soft-faced rolls. The soft roll can be a roll with a paper surface (filled roll), or a resilient roll with a polymer surface. The same calender may contain both rolls with a paper surface and rolls with a polymer surface. The supercalender typically comprises 9 to 12 rolls. The supercalender is typically an off-line calender.

The term multinip calender refers to calenders that contain several nips and that comprise nips formed between a hard-faced heated roll and a roll with an elastic surface. The roll with an elastic surface is typically a polymer coated roll. The multinip calenders can be on-line or off-line calenders. Such calenders include for example Janus calenders (Voith-Sulzer) Prosoft calenders (Küsters-Beloit) ans OptiLoad calenders (Metso Paper).

After calendering the base paper whose surface roughness after calendering is typically 1.0 to 1.3 μm, is surface sized with a surface sizing agent. The surface sizing is typically two-sided. The surface sizing is advantageously conducted as film coating. The concept of film coating refers to all such methods in which a determined amount of surface sizing agent is portioned in a suitable manner on the surface or the roll, and the surface sizing agent is transferred from the surface of the roll on the surface of the base paper. Another alternative is spray coating, and surprisingly, it was detected that blade coating is also suitable to be used in the method according to the invention, although earlier it was not possible to use blade coating in surface sizing by methods of prior art because of the tendency of the web to break. Gravure coating is also a suitable method.

After surface sizing the printing paper is dried and calendered to restore the smoothness of the surface after surface sizing, advantageously the printing paper is treated lightly in a calender with one or two nips. The calender advantageoulsy comprises a nip that is formed between a hard-faced roll and a soft-faced roll.

The manufacturing line of the printing paper according to the invention can be for example the following. The base paper can consist of normal supercalendered paper (SC) which has already been treated in a supercalender or in a multinip calender into a suitable surface roughness. The base paper is unwound from the reel in the beginning of the surface sizing line and it is surface sized with a surface sizing agent for example in a film coating unit or blade coating unit. The surface sizing agent is dried and the printing paper is calendered in a calender with one or two nips. Thereafter the printing paper that is surface-sized with surface sizing agent is reeled up.

The devices necessary for surface sizing and drying can also be added in connection with the calender. Thus, the calendered paper is conveyed from the calender to the surface sizing and drying, whereafter it is calendered lightly in a calender with one or two nips.

By means of the method according to the invention printing paper with a maximum surface roughness of 2.0 μm is advantageously manufactured. Typically, the surface roughness is under 2.0 μm, advantageously it is 1.0

to 1.2 μm. The density of printing paper is typically at least 900 kg/m^3. The aforementioned numerical values refer to the results obtained by means of the following test methods:

- surface roughness	SCAN-P 76:95
- density	SCAN-P 7:96

In the following, the invention will be described by means of examples. The results presented in the examples have been obtained with the test methods listed below.

Conditioning of sheets	SCAN-P 2:75
Grammage	SCAN-P 6:75
Moisture content	SCAN-P 4:63
Thickness	SCAN-P 7:96
Density	SCAN-P 7:96
Ash (925 °C)	SCAN-P 5:63
Air permeance (Bendtsen)	SCAN-P 60:87
Roughness (Bendtsen)	SCAN-P 21:67
Roughness (PPS)	SCAN-P 76:95
Elongation	SCAN-P 38:80
Tear index	SCAN-P 11:96
Dry surface strength (IGT)	SCAN-P 63:90
Printing ink absorption (K&N)	SCAN-P 70:95
Oil absorption (Unger)	SCAN-P 37:77
Gloss	TAPPI T480 OS-78
ISO brightness	SCAN-P 3:93
Opacity	SCAN-P 8:93
Y-value	SCAN-P 8:93
Light scattering coefficient	SCAN-P 8:93
Absorption coefficient	SCAN-P 8:93
Water penetration speed (Emco)	Measurement device of dynamic penetration, as a measurement result the greatest relative change in the transmission of ultrasound

Example 1. Offset printing papers

The properties of offset printing papers were examined in printing papers that were surface sized with a surface sizing agent before calendering and from printing papers calendered before coating with a surface sizing agent. The samples were produced under laboratory conditions. In samples O1 to O8 that are examples of papers surface sized with a surface sizing agent before calendering, uncalendered paper was used as base paper. After surface sizing the paper was calendered in a laboratory calender simulating supercalendering. The laboratory calender was a calender that comprised a nip formed between a hard heated roll and a soft paper roll. The calendering humidity was 8.5 to 9.0%, the number of nips was 8, the temperature of the heated rolls 75° and the nip pressure 200 kN/m.

In the samples O1 and O2 aqueous acrylic copolymer dispersion (Basoplast 335 D, BASF AG) was used as surface sizing agent, in samples O3 and O4 carboxy-methyl cellulose (in sample O3 Finnfix 10, Noviant Oy, in sample O4 Finnfix 5, Noviant Oy), in samples O5 ja O6 starch (Raisamyl 404N, Raisio Chemicals Oy) ja in samples O7 ja O8 cationic wax dispersion (Raibond 23 CA, Raisio Chemicals Oy). The test results are shown in Table 1.

In samples O9 to O16 that are examples of papers surface sized with a surface sizing agent after calendering, calendered paper was used as base paper. After coating the paper was calendered only lightly. The calendering humidity was 5.5 to 6.0%, the number of nips was 2, the temperature of the heated rolls 75°C and the nip pressure 200 kN/m.

The surface sizing agents were in sample O9 aqueous acrylic copolymer dispersion (Basoplast 335 D, BASF AG), in sample O10 carboxy-methyl cellulose (Finnfix 5, Noviant Oy), in sample O11 starch (Raisamyl 404 N, Raisio Chemicals Oy), in sample O12 cationic wax dispersion (Raibond 23 CA, Raisio Chemicals Oy), in sample O13 a mixture of carboxy-methyl cellulose and acrylic copolymer dispersion (Finnfix 5 and Basoplast 335 D), in sample O14 a mixture of starch and acrylic copolymer dispersion (Raisamyl 404 N and Basoplast 335 D), in sample O15 a mixture of starch and styrene acrylate latex (Raisamyl 404 N and XZ 94329.02, DOW Oy)

and in sample O16 a mixture of starch and styrene butadiene latex (Raisamyl 404 N and DL 966, DOW Oy). The test results are shown in Table 2.

In printing papers that were calendered before surface sizing, a smoother surface was attained than in paper manufactured in the conventional manner by using smaller amounts of surface sizing agent, compare for example the amounts of surface sizing agents and PPS 10 surface roughness values in samples O1, O2 and O9, in samples O4 and O10, in samples O5, O6 and O11 and samples O7, O8 and O12. By examining the above-mentioned samples it is also possible to notice that the absorption of the printing ink is in samples calendered before surface sizing on the same level than in samples surface sized without calendering, although the used amounts of surface sizing agent are multiple in the samples surface sized without calendering when compared to samples calendered before surface sizing.

Example 2. Offset printing papers

The printing properties of offset printing papers manufactured by means of the method according to the invention were examined in samples manufactured in pilot scale. The base paper in the samples OP1 to OP16 was supercalendered 56g/m^2 paper.

The samples Ref. 1 and Ref. 2 are reference samples. Ref. 1 is LWC paper intended for offset printing and Ref. 2 is SC paper intended for offset printing. In samples OP1 and OP2 the surface treatment agent is wax dispersion (Raibond 35 CA), in samples OP3 and OP4 carboxy-methyl cellulose (Finnfix 5), in samples OP5 and OP6 cationic surface sizing starch (Raisamyl 404 N), in samples OP7 and OP8 a mixture of starch and acrylic copolymer dispersion in a ratio of 80/20% by weight (Raisamyl 404 N and Basoplast 335 D), in samples OP9 and OP10 a mixture of starch and styrene/butadiene latex in a ratio of 80/20 % by weight (Raisamyl 404 N and DL 966), in samples OP11 ja OP12 a mixture of starch and styrene/acrylate latex in a ratio of 80/20% by weight (Raisamyl 404 N and XZ 94329.02), in samples OP13 ja OP14 a mixture of caboxy-methyl cellulose and acrylic copolymer dispersion in a ratio of 80/20% by weight (Finnfix 5 and Basoplast 335 D) and in samples OP15 and OP16 a

mixture of starch and plastic pigment in a ratio of 80/20% by weight (Raisamyl 404 N and Ropaque HP 1055). The test results are shown in Table 3.

The results show that the dry surface strenght values were increased in all surface sizing agents that were used when compared to the reference samples. Most of the surface treatment agents reduced the ink requirement, increased the tone value of the print and decelerated the penatration of water in the paper.

Example 3. Gravure papers.

Properties of gravure papers were examined in the reference samples and in samples that were calendered before surface sizing.

Samples Ref. 3 and Ref. 4 and Ref. 5 are reference samples that are manufactured by conventional methods to be used as gravure papers. Ref 3 is 52 g/m^2 SC-paper, Ref.4 is 56 g/m^2 SC-paper and Ref.5 is 51 g/m^2 LWC-paper.

The base paper in the samples R1 to R6 according to the invention was 52 g/m^2 supercalendered paper, the surface roughness (PPS 10) of which was ≈1,14 µm. When the base paper had been surface sized, it was calendered under laboratory conditions to obtain the same surface roughness (PPS 10) than in supercalendered gravure papers (Gradek laboratory calender). The paper was calendered in two nips, the temperature was 75°C and the pressure 4 MPa. The moisture content of the paper before calendering was ≈ 6 %.

The paper was surface sized in a blade coating unit in a laboratory in such a manner that only one side of the paper was surface sized. In sample R1 the surface sizing agent was only water, in sample R2 carboxy-methyl cellolose (Finnfix 5, Noviant Oy), in sample R3 cationic wax dispersion (Raibond 35 CA, Raisio Chemicals Oy), in sample R4 a mixture of carboxy-methyl cellulose and cationic wax dispersion (Finnfix 5 and Raibond 35 CA in a ratio of 50% / 50%), in sample R5 a mixture of carboxy-methyl cellulose (Finnfix 5) and polyethylene glykol in a ratio of 50 % / 50 % and in sample R6 a mixture of carboxy methyl cellulose (Finnfix 5) and basic

paste in a ratio of 50 % / 50 %. The basic paste contains 55 parts of talc, 45 parts of kaoline and 5.5 parts of polyvinyl acetate acrylate latex, in which the acrylate is butylacrylate (Raisional 388, Raisio Chemicals Oy). The target pH in the surface treatment agent of sample R6 was 9.5. The results of the tests are shown in tables 4 to 6.

The absorption values of the printing paper manufactured by means of the method according to the invention were considerably reduced when compared to the reference sample. The reduction in the values was at least 75 %.

The tensile index remained the same or improved slightly when compared to conventional supercalendered gravure paper, the tensile energy absorption index, in turn, was significantly improved. The tear index was dependent on the surface sizing agent that was used, and it was at its highest when cationic wax dispersion was used as surface sizing agent, said wax dispersion being an aqueous mixture of starch and calcium stearate. The amount of starch in the wax dispersion was 10 %.

The effect of the surface sizing agent on the optical properties was monitored by measuring brightness and opacity. The brightness was dependent on the chemical that was used. The surface sizing agent did not have much effect on opacity.

Table 6 shows the results of the printability of the printing paper according to the invention. In gravure tests a GRI gravure machine, Shell Cup S2 ink viscosity measurement and black test ink (Sun Chemical) were used.

The printing ink was manufactured in such a manner that 700 ml of toluene was added in 1800 grammes of test ink supplied by the factory. The viscosity was measured with a viscometer and time measurement. The time should be 25 seconds.

The printing ink was poured in a water container. The sample was attached on a printing base and it was printed.

The results show that the tone level of the printing ink and the gloss of the print are improved when the method according to the invention is used in

the manufacture. The amount of missing dots largely depends on the surface sizing agent that is used. The structure of the paper coated with surface sizing agent is very closed, because print through is reduced. The results obtained from the air permeance, water penetration speed and printing ink absorption also refer to the closed quality of the surface. The act of supplementing the sample R6 with a mineral agent did not result in considerable advantages in the printing properties.

The invention is not restricted to the description above, but it may vary within the scope of the claims. The main aspect in the present invention is that by calendering the base paper sufficiently before surface sizing in such a manner that a permanent change in the surface roughness is attained, it is possible to attain printing paper with good quality with only a small amount of surface sizing agent. By means of selecting a suitable surface sizing agent it is possible to make the printing paper suitable for offset or gravure printing.

Example 1. Properties of surface-sized and calendered offset printing paper

Property	O1	O2	O3	O4	O5	O6	O7	O8
Amount of surface sizing agent (g/m^2)	0.7	3.5	0.6	2.4	1.8	4.3	0.8	3.7
Grammage (g/m^2)	58.2	60.6	57.4	59.6	59.1	61.6	58.3	60.8
Thickness (µm)	56.0	54.3	46.0	47.0	47.4	48.3	47.6	47.6
Bulk (m^3/kg)	0.96	0.90	0.80	0.79	0.80	0.78	0.82	0.78
Density (kg/m^3)	1040	1116	1249	1268	1246	1275	1226	1277
Roughness (Bendtsen), top surface (ml/min)	31	19	33	33	31	18	40	23
Air permeance (Bendtsen) (ml/min)	9	1	3	1	1	1	3	1
Gloss, top surface (%)	33.8	44.2	38.4	45.3	51.1	65.6	39.6	43.4
Roughness (PPS-10), top surface (µm)	1.96	1.66	1.44	1.38	1.22	1.21	1.33	1.16
Printing ink absorption (K&N), top surface (%)	8.8	5.6	10.9	6.1	5.0	3.2	8.6	4.0
Oil absorption, top surface (g/m^2)	1.23	0.73	1.08	0.80	0.43	0.08	1.10	0.30
Water penetration speed (Emco), S value (%) r/s	8.3	2.0	35.0	14.8	12.5	7.0	20.0	13.3
Dry surface strength (IGT), medium-viscous oil, top surface (m/s)	0.38	0.35	0.55	0.64	0.68	0.36	0.63	0.80
Dry surface strength (IGT), low-viscous oil, top surface (m/s)	2.07	1.66	2.65	4.00	3.58	2.53	2.11	3.52
ISO brightness, top surface (%)	66.6	61.9	66.6	64.9	64.9	64.6	67.3	65.9
Dominant wavelength, top surface (nm)	573.0	573.0	572.0	573.0	572.0	572.0	573.0	574.0
Ink purity, top surface (%)	5.9	7.7	4.0	4.2	4.3	4.1	3.8	3.9
Y value, top surface (%)	72.8	69.8	70.6	68.9	69.1	68.6	71.0	69.6
Opacity, top surface (%)	94.0	92.5	90.8	90.8	90.5	91.1	91.5	91.6
Light scattering coefficient, top surface (m^2/kg)	56.7	44.8	43.8	40.0	40.1	39.1	45.3	42.0
Absorption coefficient, top surface (m^2/kg)	2.88	2.94	2.68	2.81	2.78	2.81	2.69	2.79

Table 2. Properties of calendered and surface-sized printing paper

Property	O9	O10	O11	O12	O13	O14	O15	O16
Amount of surface sizing agent (g/m^2)	0.4	0.4	0.3	0.4	0.5	0.8	1.0	0.8
Grammage (g/m^2)	56.8	56.8	56.1	57.2	57.1	57.6	57.2	57.1
Thickness (μm)	48.0	46.0	46.0	46.0	45.5	45.7	46.3	48.0
Bulk (m^3/kg)	0.84	0.81	0.82	0.80	0.80	0.79	0.81	0.84
Density (kg/m^3)	1184	1234	1220	1243	1254	1260	1236	1189
Roughness (Bendtsen), top surface (ml/min)	21	17	17	20	19	12	13	18
Air permeance (Bendtsen) (ml/min)	2	7	4	7	0	0	1	1
Gloss, top surface (%)	48.6	50.2	52.5	49.9	51.8	62.8	64.0	63.1
Roughness (PPS-10), top surface (μm)	1.12	1.06	0.99	0.99	1.08	1.11	1.06	1.06
Printing ink absorption (K&N), top surface (%)	5.6	8.4	5.6	11.4	5.8	3.4	4.2	3.5
Oil absorption, top surface (g/m^2)	0.73	1.20	-	1.68	0.40	0.20	0.20	0.30
Water penetration speed (Emco), S value (%) r/s	21.0	56.0	56.0	73.0	18.9	7.5	7.7	7.3
Dry surface strength (IGT), low-viscous oil, lop surface (m/s)	1.13	1.54	1.66	1.30	3.35	2.96	2.47	3.00
ISO brightness, top surface (%)	66.0	66.4	66.4	66.7	65.6	64.3	65.0	64.7
Dominant wavelength, top surface (nm)	572.0	572.0	572.0	572.0	572.1	572.1	571.8	571.8
Ink purity, top surface (%)	5.1	4.4	4.4	4.3	4.6	4.8	4.6	4.7
Y value, top surface (%)	71.3	70.9	70.9	71.1	70.2	69.0	69.5	69.4
Opacity, top surface (%)	91.6	91.3	90.7	91.6	90.4	90.4	90.3	90.1
Light scattering coefficient, top surface (m^2/kg)	47.4	45.9	44.9	46.6	42.6	40.7	41.4	40.9
Absorption coefficient, top surface (m^2/kg)	2.73	2.74	2.68	2.73	2.70	2.83	2.77	2.76

Table 3. Properties of offset printing papers

Sample	Amount of surface sizing agent (g/m^2)	Dry surface strength (IGT), top surface (m/s)	Ink requirement (g/m^2)	Print tone level	Water penetration speed (Emco), S value, top surface (%) r/s
Ref.1	10.2	1.27	1.1	1.81	9.6
Ref.2	-	0.83	1.4	1.42	167.0
OP1	2.51	2.93	1.4	1.40	24.0
OP2	1.70	1.78	1.4	1.37	77.0
OP3	1.81	4.57	1.3	1.55	11.6
OP4	1.35	2.36	1.4	1.40	50.0
OP5	1.83	3.34	1.2	1.57	15.9
OP6	0.90	3.32	1.2	1.39	50.0
OP7	1.96	3.64	1.2	1.53	9.0
OP8	2.31	3.49	1.2	1.51	21.0
OP9	1.26	3.36	1.1	1.62	11.4
OP10	1.17	3.18	1.4	1.43	36.0
OP11	2.39	3.69	1.0	1.73	9.9
OP12	2.25	3.24	1.2	1.53	19.5
OP13	1.82	4.03	1.3	1.46	11.7
OP14	1.49	2.48	1.5	1.37	43.0
OP15	2.73	5.05	1.0	1.74	6.9
OP16	1.63	3.11	1.3	1.51	45.0

Table 4. Properties of gravure paper.

Property	Ref.3.	R1	R2	R3	R4	R5	R6
Dry matter content (%)			9,0	14,4	11,4	17,9	15,4
Viscosity (mPas)				174	980	1560	506
Grammage (g/m^2)	52.2	51.9	52.9	52.6	52.8	53.4	53.1
Amount of surface sizing agent (g/m^2)			0.70	0.33	0.57	1.16	0.84
Thickness (µm)	44	43	44	44	44	44	44
Density (kg/m^3)	1187	1206	1203	1195	1200	1214	1206
Bulk (m^3/kg)	0.842	0.829	0.831	0.837	0.833	0.824	0.829
Roughness (PPS-10) (µm)	1.14	1.07	1.12	0.93	1.02	1.09	1.21
Roughness (PPS-20) (µm)	0.86	0.84	0.86	0.69	0.75	0.80	0.92
PPS 10/PPS 20	1.33	1.27	1.30	1.35	1.36	1.36	1.32
Gloss (Hunter) (%)	46.0	42.7	48.9	48.0	44.8	50.3	35.8
Roughness (Bendtsen) (ml/min)	24	25	4	11	4	2	2
Stiffness (Kodak) (mNm)	0.048	0.043	0.062	0.043	0.049	0.058	0.053
Water penetration speed (Emco), S value (%)	159	139	16	34	17	21	12
Printing ink absorption (%)	14.6	15.8	2.5	3.5	2.0	2.7	2.8

Table 5. Properties of gravure paper.

Property	Ref.3.	R1	R2	R3	R4	R5	R6
Tensile index, machine direction (Nm/g)	42,3	43,0	45,1	42,0	44,8	44,1	45,4
Elongation, machine direction (%)	1.04	1.21	1.25	1.18	1.26	1.25	1.25
Tensile energy absorption index, machine direction (J/kg)	272	322	350	306	351	343	352
Tensile stiffness index, machine direction (MNm/kg)	6.17	5.56	5.69	5.47	5.62	5.70	5.63
Tear index, machine direction (mNm^2/g)	3.18	3.16	3.15	3.37	3.22	3.03	3.35
Brightness ts (%)	67.6	67.7	66.3	67.3	67.1	66.5	67.2
Y-value ts (%)	72.1	72.3	71.1	71.9	71.8	71.2	72.0
Opacity ts (%)	91.2	91.1	91.0	91.1	91.0	90.9	91.2
Light scattering coefficient ts (m^2/kg)	51.3	51.8	48.6	50.3	49.7	48.1	50.5
Light absorption coefficient ts (m^2/kg)	2.76	2.76	2.85	2.77	2.76	2.81	2.75
Dominant wavelength (nm)	573.1	572.8	573.0	573.1	573.1	573.3	573.0
Excitation purity ts (%)	4.41	4.38	4.80	4.46	4.59	4.68	4.69
Dry surface strength (IGT) (m/s)	57	71	258	215	242	229	224

Table 6. Properties of gravure paper.

Property	Ref.3.	Ref.4.	Ref.5.	R1	R2	R3	R4	R5	R6
Printing ink tone level	1.86	2.03	1.86	1.82	2.02	2.03	2.00	2.02	2.02
Print through tone level	0.066	0.063	0.067	0.070	0.053	0.064	0.056	0.060	0.062
Print transparency (%)	3.6	3.1	3.6	3.9	2.6	3.2	2.8	2.9	3.0
Printed gloss (%)	66.4	82.4	70.5	62.8	74.8	74.7	73.8	73.8	72.2
Number of missing dots (dots/cm^2)	24	1207	24	16	130	not known	12	151	18
Entropy	1.83	1.27	0.90	1.79	1.77	1.85	1.78	1.64	1.69